



SKJ Education

LC HL PHYSICS FOUNDATION

PROGRAM: WEEK 2

FORCES & MOTION

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LC HL PHYSICS – FOUNDATION PROGRAM

Week 2: Forces Motion

Learning Objectives

- **2.1:** To state and apply Newton's Three Laws of Motion to real-world scenarios.
- **2.2:** To use the equations of motion (suvat) to solve problems involving constant acceleration in a straight line.
- **2.3:** To resolve vectors into components and apply this to analyse projectile motion.
- **2.4:** To draw and interpret free-body diagrams to represent forces acting on an object.

Key Terms - Week 2

- **Newton's Laws of Motion:** Three fundamental principles that describe the relationship between a body and the forces acting upon it.
- **First Law (Law of Inertia):** An object at rest remains at rest, and an object in motion remains in motion with a constant velocity, unless acted upon by an external force.
- **Second Law:** The force applied to an object is equal to the mass of the object multiplied by its acceleration ($F = ma$).
- **Third Law:** For every action, there is an equal and opposite reaction.
- **Equations of Motion (suvat):** A set of equations used to solve problems involving constant acceleration in a straight line: $v = u + at$, $s = ut + \frac{1}{2}at^2$, $v^2 = u^2 + 2as$, $s = \frac{1}{2}(u + v)t$.
- **Projectile Motion:** A type of motion where an object moves in a curved path under the influence of gravity, which can be analysed by resolving the motion into horizontal and vertical components.
- **Free-Body Diagram:** A graphical representation of the forces acting on an object, used to identify the net force and resulting acceleration.
- **Vector Components:** The resolution of a vector into its constituent parts, often along perpendicular axes (e.g., horizontal and vertical).

Weekly Challenge: Investigate a real-world scenario that illustrates the application of Newton's Laws, such as a car accelerating or a projectile in motion. Use the equations of motion and/or vector components to analyse the situation and share your findings on Google Classroom.



WEEK 2 STUDY PLAN

Day	Activities & Time Commitment	✓	Rating (1-10)
Monday	- Review Learning Objectives (5 min) - Rank your current ability (5 min) - Review Key Terms (10 min) - Complete Exercise A1 (15 min) <i>Focus: PREPARATION</i>		
Tuesday	- Complete Exercises A2 & A3 (60 min) - 1-hour online lesson (60 min) <i>Focus: QUESTIONING</i>		
Wednesday	- Reflect on content so far (what has been challenging?) (10 min) - Plan remaining study sessions (10 min) <i>Focus: PROCESSING</i>		
Thursday	- Complete Exercise B (50 min) <i>Focus: EXPERIMENTAL THINKING</i>		
Friday	- Complete Exercise C (40 min) <i>Focus: ERROR ANALYSIS</i>		
Saturday	- Complete Exam Question Assessment (D) (60 min) <i>Focus: EXECUTION</i>		
Sunday	- Correct assessment (30 min) - Complete self-reflection (15 min) - Plan next week (15 min) <i>Focus: REFLECTION & RECHARGING</i>		

Study Tips for Success

- **Active Recall:** After studying, close your notes and write down **everything** you remember. Force your brain to grow.
- **Spaced Repetition:** Review concepts **multiple times** over several days.
- **Physics in Action:** Look for **real-world examples** of the concepts you're learning.
- **Ask Questions:** Don't hesitate to ask for help when concepts are unclear. Reach out via *Google Classroom* or email; *steven@skjeducation.com*.
- **Celebrate Progress:** **Acknowledge your improvements**, no matter how small.



A1. Proficiency Drills

Learning Focus: Build a rock-solid foundation in (i) Newton’s Laws, (ii) constant-acceleration “SUVAT” equations, (iii) vector resolution & free-body diagrams. The notes below *teach first*, then you practise.

Task #1 – Newton’s Three Laws (Core Concept)

Quick Reference Card

1st Law – Inertia

No external force no change in velocity. *Key signpost: “constant speed in a straight line”.*

2nd Law – $\vec{F} = m\vec{a}$

Net force *causes* acceleration. Double the force \Rightarrow double the acceleration (same mass).

3rd Law – Action–Reaction

If object A pushes B with \vec{F} , B pushes A with $-\vec{F}$. Forces act on *different* objects and are **simultaneous**. Negative force simply means force in the “*opposite direction*”.

Your Turn (fill table):

Scenario	Which Law?	Why? (1 line)
(a) Coin stays on card when card is flicked away.		
(b) Gun recoils backward as bullet exits.		
(c) Rocket accelerates by expelling gas.		
(d) Car of mass m accelerates: $a = (F_{\text{engine}} - D)/m$.		
(e) Two skaters push and glide apart on ice.		
(f) Passenger lurches forward when bus brakes.		
(g) Lift rises when cable tension $> mg$.		
(h) Satellite coasts in space with engines off.		

! Pitfall Alert: Don't confuse 3rd-law pairs with balanced forces in equilibrium. 3rd-law forces act on *different bodies*.

Task #2 – UVATS Mastery (Essential Calculation Skill)

UVATS Toolbox

$$v = u + at \quad (1)$$

$$s = ut + \frac{1}{2}at^2 \quad (2)$$

$$v^2 = u^2 + 2as \quad (3)$$

$$s = \frac{1}{2}(u + v)t \quad (4)$$

$$s = vt - \frac{1}{2}at^2 \quad (5)$$

Strategy: List u, v, a, s, t . Select one equation containing *only one* unknown. Solve.

Worked Mini-Example. A cyclist brakes from 12 to 5 m s^{-1} in 3.0 s . Find a and stopping distance.

- Known: $u = 12$, $v = 5$, $t = 3$.
- Eqn (1): $a = (v - u)/t = (5 - 12)/3 = -2.3 \text{ m s}^{-2}$.
- Eqn (4): $s = \frac{1}{2}(u + v)t = 0.5(17)(3) = 25.5 \text{ m}$.

Practice Six-Pack (show full working):

1. Car: $u = 6.0 \text{ m s}^{-1}$, $v = 20.0 \text{ m s}^{-1}$, $t = 4.0 \text{ s}$. Find a and s .
2. Runner: $u = 0$, $a = 2.5 \text{ m s}^{-2}$, $t = 3.6 \text{ s}$. Find v and s .
3. Stone upward $u = 14 \text{ m s}^{-1}$; $g = 9.8$. (i) Time to top, (ii) max height.
4. Train slows $22 \rightarrow 5 \text{ m s}^{-1}$ over 150 m . Find a and t .
5. Bicycle: rest \rightarrow cover 78 m in 12 s . Determine a and final v .
6. Ball drop $h = 45 \text{ m}$; find impact speed and time.

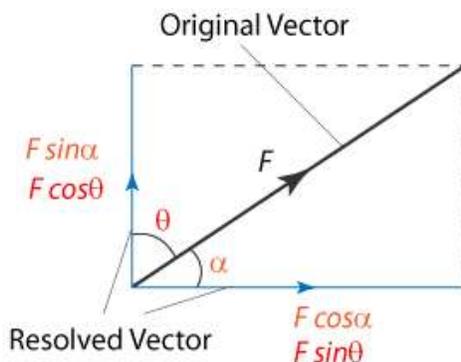
► **Check Yourself:** After solving, estimate if answer is “sensible” (e.g. upward stone should take $\sim 1.5 \text{ s}$ to stop, not 15 s).

Task #3 – Vector Components & Free-Body Diagrams (Common Pitfall)

Resolving a Force

You will have to use Pythagoras' Theorem to resolve a force into its **horizontal and vertical components**. For \vec{F} at angle θ above $+x$: $F_x = F \cos \theta$ (along x), $F_y = F \sin \theta$ (upwards).

Always use cos with the axis the angle touches.



- Resolve 35 N at 30° above horizontal.
- Resolve 80 N at 25° pulling upward.
- Projectile $v = 28 \text{ m s}^{-1}$, $\theta = 40^\circ$: find v_x, v_y .

Free-Body Diagrams (FBD). Draw *only forces*, not velocities.

- 4.0 kg box on horizontal floor, pulled by force from part (a), $\mu_k = 0.25$.
- 70 kg skier on 15° slope, friction 55 N.

! Common Error: Weight *always* points down; normal force is *perpendicular* to surface, not always vertical.

Task #4 – Mixed Practice (All Objectives Together)

Solve fully; state law/equation used.

- Towing System** – 1200 kg car pulls 800 kg trailer. Engine force 2400 N, drag 600 N. Find (i) acceleration, (ii) tow-bar tension (draw FBDs).
- Projectile** – Basketball 0.60 kg launched 12 m s^{-1} at 35° . Ignore air resistance. (i) Time of flight, (ii) horizontal range, (iii) speed at impact.
- Elevator** – Mass 900 kg accelerates upward at 1.2 m s^{-2} . Find cable tension.
- Stopping Distance** – Puck 0.17 kg on ice ($F_f = 0.25 \text{ N}$) initial $v = 7.0 \text{ m s}^{-1}$: find stopping distance and time.
- Inclined Plane** – 3.0 kg block on 20° slope, $\mu_k = 0.15$: calculate acceleration; sketch FBD.
- Momentum Link** – Cannon 1500 kg fires 5.0 kg shell at 300 m s^{-1} . Find recoil speed (horizontal).
- Vector Challenge** – Two forces: $F_1 = 40 \text{ N}$ East, $F_2 = 25 \text{ N}$ at 60° North of East. Find resultant magnitude & bearing.
- Concept Check** – Explain why 3rd-law forces never cancel in $\sum \vec{F} = m\vec{a}$ for a *single* object.

Numerical Answers (rounded): 1 (i) $a = 1.3 \text{ m s}^{-2}$, 1 (ii) $T = 520 \text{ N}$; 2 (i) $t = 1.4 \text{ s}$, 2 (ii) $R = 11 \text{ m}$, 2 (iii) 12 m s^{-1} (same speed); 3) $T = 1.1 \times 10^4 \text{ N}$; 4) $s = 196 \text{ m}$, $t = 56 \text{ s}$; 5) $a = 2.3 \text{ m s}^{-2}$ down slope; 6) recoil $v = 1.0 \text{ m s}^{-1}$; 7) resultant 59 N at 24° N of E.

D. Weekend Assessment – Past Exam Questions

Learning Focus: Applying learning to exam questions under timed conditions.

Assessment Instructions

Answer as many questions as you can in 60 minutes - try to solve them alone first before checking your notes!

Past Exam Questions

Question 1 (2016, Q5) A sprinter starts from rest and accelerates uniformly for 3 seconds until she reaches a velocity of 10 m s^{-1} . She then runs at a constant velocity for 6 seconds before decelerating. Sketch a velocity-time graph of her motion.

Question 2 (2014, Q12(a)) A bus leaves a bus stop and accelerates from rest at 0.5 m s^{-2} to reach a speed of 15 m s^{-1} . It maintains this speed for 100 seconds. When it approaches the next stop, the driver brakes uniformly to bring the bus to a stop in 20 seconds.

- Calculate the time it took the bus to reach its top speed.
- Calculate the distance it travelled while at its top speed.
- Calculate the acceleration required to bring the bus to a stop.

Question 3 (2019, Q5) A book decelerates moving to the right on a horizontal table. Draw a labelled diagram to show the forces acting on the book as it moves across the table.

Question 4 (2003, Q12(a))

- State Newton's second law of motion.
- A skydiver jumps from an aircraft. He reaches a constant speed of 50 m s^{-1} after falling through a height of 1500 m. Calculate their average vertical acceleration.
- If the mass of the skydiver is 90 kg, what is the magnitude and direction of the average resultant force acting on him?

Question 5 (2011, Q5) A car of mass 1500 kg is travelling at a constant velocity of 20 m s^{-1} . What force is required to stop it in a distance of 50 m?

Question 6 (2019, Q11) A ball of mass 110 g is travelling at a speed of 4 m s^{-1} . It rebounds from a wall and travels in the opposite direction at the same speed. The ball was in contact with the wall for 0.2 seconds. Use Newton's laws of motion to calculate the force exerted by the wall on the ball.

Question 7 (2014, Q6) A force of 5.3 kN is applied to a golf ball by a club. The mass of the ball is 45 g and the ball and club are in contact for 0.54 ms. Calculate the speed of the ball as it leaves the club.

Question 8 (2002, Q12(a))

- State the principle of conservation of momentum.
- A spacecraft of mass 50 000 kg is approaching a space station at a constant speed of 2 m s^{-1} . The spacecraft must slow to a speed of 0.5 m s^{-1} for it to lock onto the space station. Calculate the mass of gas that the spacecraft must expel at a speed 50 m s^{-1} for the spacecraft to lock onto the space station. (The change in mass of the spacecraft may be ignored.)



Self-Assessment

After completing the assessment:

- Grade your work honestly
- Identify areas needing improvement
- Scan and submit via Google Classroom
- Reflect on your performance in your weekly reflection

Another excellent week of work completed - ***well done!*** You are another step closer to *smashing your exams*, and another week closer to your summer holidays!

Weekly Reflection Zone

What worked well this week?

What challenges did I face?

What surprised me the most this week?

Key physics concepts I want to review:

Goals for next week: